REMARKS

Enclosed herewith is a Substitute Specification in which the specification as filed has been amended in various places to correct typographical and grammatical errors, and also to add section headings.

In support of the above, enclosed herewith is a copy of the specification as filed marked up with the above changes.

The undersigned attorney asserts that no new matter has been incorporated into the Substitute Specification.

The claims have been amended to more clearly define the invention as disclosed in the written description. In particular, claim 10 has been cancelled, while claim 4 has been made a proper independent claim including the limitations of claims 1 and 2. In addition, claim 7 has been made dependent on claim 5. Furthermore, new claim 11, depending from claim 6, presents the preferable limitation cancelled from claim 6, while new claim 12, depending from claim 8, presents the exemplary embodiment cancelled from claim 8. In addition, claims 1-9 have been amended for clarity.

Applicants believe that the above changes answer the Examiner's 35 U.S.C. 112, paragraph 2, rejection of claims 7, 8 and 10, and respectfully request withdrawal thereof.

The Examiner has rejected claims 1-3 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent 5,528,695 to Klippel. The Examiner has further rejected claim 8 (and apparently claim 9)

under 35 U.S.C. 103(a) as being unpatentable over Klippel in view of U.S. Patent 4,944,015 to Juve et al.

Applicants acknowledge that the Examiner has found claims 4-6 allowable over the prior art of record, and in view of the above changes, Applicants believe that claims 4-7 shown now be allowed.

The Klippel patent discloses a predictive protection arrangement for electroacoustic transducer in which, as shown in Fig. 1, an input audio signal is applied to a linear filter 3 (which may be a low-pass filter) and an envelope detector 4. An output from the envelope detector 4 is applied to a control input of a controller 5, to which the input audio signal is applied, for controlling a transfer characteristic of the controller 5. The output from the envelope detector 4 is an amplitude signal which corresponds to the peak value of the displacement of a loudspeaker coupled to an output of the controller 5. If the amplitude signal exceed a defined limit, the controller 5 is activated to change the input signal (col. 3, lines 10-44).

The subject invention, as claimed in, for example, claim 1, includes filter means for dividing the input audio signal into a plurality of frequency bands, and amplifier/attenuator means coupled to the filter means. Processing means determines the audio power in each of the frequency bands and selectively controls the

amplifier/attenuator means in at least one frequency band in response to the determined audio power.

Applicants submit that Klippel neither shows nor suggests the filter means dividing the audio signal into a plurality of frequency bands, nor the processing means selectively controlling the amplifier/attenuator means in at least one of the frequency bands in response to the determined audio power.

The Juve et al. patent discloses an audio compression circuit for television audio signals in which series resistors 14 are shown in series between an amplifier 22 and a loudspeaker 12, which is selectively shunted, via an enable switch 20, by a detection and level adjustment circuit 16 and shunting circuit 18.

In the current Office Action, the Examiner equates the series resistors 14 of Juve et al. with the measuring element of the subject invention. Applicants submit, however, that the measuring element is arranged such that it provides an indication of the "actual impedance data" of the loudspeaker. This is not done by the series resistors 14 of Juve et al. As noted at col. 3, lines 27-31, "the series resistors 26 and 28 of the resistor circuit 14 (FIG. 2) provide the audio amplifier means 22, which produces a source voltage, a minimum load impedance and establish a minimum series resistance at node 24 for the shunt circuit 18." Hence, the series resistors 14 of Juve et al. do not provide any information concerning the loudspeaker. Further, the series resistors 14 of

Juve et al. are arranged in series with the amplifier and the loudspeaker, while the measuring element of the subject invention connects the loudspeaker to ground, and the junction between the loudspeaker and the measuring element is connected to the processing means.

Further, Applicants submit that Juve et al. does not supply that which is missing from Klippel, i.e., the filter means dividing the audio signal into a plurality of frequency bands, nor the processing means selectively controlling the amplifier/attenuator means in at least one of the frequency bands in response to the determined audio power.

In view of the above, Applicants believe that the subject invention, as claimed, is neither anticipated nor rendered obvious by the prior art, either individually or collectively, and as such, is patentable thereover.

Applicants believe that this application, containing claims 1-9, 11 and 12, is now in condition for allowance and such action is respectfully requested.

Respectfully submitted,

by _____
Edward W. Goodman, Reg. 28,613
Attorney
Tel.: 914-333-9611

CERTIFICATE OF MAILING

It is hereby certified that this correspondence is being deposited with the United States Postal Service as First-class mail in an envelope addressed to:

COMMISSIONER OF PATENTS AND TRADEMARKS
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

On May 10, 2004

By Burnett James

10/509

#7 (N.E.) 5/19/04

LOUDSPEAKER PROTECTION SYSTEM HAVING FREQUENCY BAND SELECTIVE AUDIO POWER CONTROL

BACKGROUND OF THE INVENTION

Field Of The Invention

[0001] The present invention relates to a loudspeaker protection system comprising filter means for defining one or more frequency bands of an audio signal.

[0002] The present invention also relates to a audio set provided with a loudspeaker protection system.

Description Of The Related Art

[0003] Such a loudspeaker protection system is known from German Offenlegungsschrift DE-AS 24 15 816, and can be applied in compact, small size, ~~so~~ so-called micro, mini or midi audio sets. The known loudspeaker protection system comprises respective bandwidth controllable filter means, whose individual bandwidths, in particular, in the low and high frequency bands, are controllable by means of a control means coupled to the loudspeaker of the system. In order to thermally protect the loudspeaker against short or long lasting overload, the filter means can be influenced by decreasing the output level of the audio signal for the loudspeaker. Merely decreasing the loudspeaker output level within, e.g., a bass frequency range may provide some protection, but, at

the same time, it is a disadvantage of the known loudspeaker protection system that it sacrifices loudspeaker output power ~~unnecessary~~ unnecessarily and thus fails to make effective use of available loudspeaker output power. In addition, this sacrifice of output power is a major commercial disadvantage, in particular, for the younger--aged target group of these audio sets.

SUMMARY OF THE INVENTION

[0004] Therefore it is ~~the aim~~an object of the present invention to provide a loudspeaker protection system, which is made effective for the specified purpose of protecting the loudspeaker only, without unnecessary ~~effecting~~ affecting the full power range available for the loudspeaker.

[0005] ~~Thereto~~ Therefore, the loudspeaker protection system according to the present invention is ~~characterised~~ characterized in that the loudspeaker protection system further comprises controllable amplifier/attenuator means coupled to the filter means, and processing means coupled to control the amplifier/attenuator means, such as to determine audio power in at least one of said frequency bands representing relevant loudspeaker protection information used for selective audio power control in said at least one frequency band.

[0006] By determining the respective audio output powers for the loudspeaker in respective frequency bands, accurate information becomes available about the variety of sources of dangers which are connected to loudspeakers, such as, short- and ~~long~~ long-term overload, as well as excessive excursion or displacement of the loudspeaker cone or coil, which is a ~~well~~ well-known source of all kinds of distortion in reproduced loudspeaker sounds. Thus, a multi-purpose loudspeaker protection system is made available, which can be dedicated to its specific protection functions without unnecessary ~~effecting~~ affecting the full power range available for the loudspeaker. Audio power in respective frequency bands has thus proven to provide a reliable source of loudspeaker protection information, so that no audio output power is sacrificed needlessly and the maximum audio output performance can be delivered without endangering the loudspeaker.

[0007] One embodiment of the loudspeaker protection system according to the invention is ~~characterised~~ characterized in that the processing means are equipped to determine the audio power S_j in frequency band j in proportion to:

$$v_{jtop}^2 * R\{Y_j\},$$

where v_{jtop} is the peak value of the amplitude of the frequency components in frequency band j, and $R\{Y_j\}$ is the real part of the electric admittance of the loudspeaker in frequency band j.

[0008] Advantageously, v_{jtop} can be derived from the respective outputs of the amplifier/attenuator means, and $R\{Y_j\}$ can either be estimated or predicted, or can, more accurately, actually be measured in a further embodiment by means of a measuring element arranged in series with the loudspeaker.

[0009] A further embodiment of the loudspeaker protection system according to the invention is ~~characterised~~ characterized in that in the loudspeaker protection system, $j = 1, 2, 3 \ldots n$, where n equals the number of frequency bands wherein the frequency spectrum of the audio signal is divided.

[0010] Starting with $j = 1$, which is the frequency band containing the lowest frequency components of the audio signal, this band contains relevant information~~,~~ which is a good estimate for the resistance of the voice coil of the loudspeaker. This resistance depends on and generally increases with the actual temperature of the voice coil. ~~So~~ Hence, the information contained in audio power S_1 may be used to activate the amplifier/attenuator means to function as a slow term thermal protection. Similarly, audio power S_2, for example, containing frequency components around the ~~so~~ so-called Helmholtz frequency (e.g., between 25 Hz and 85 Hz for a bass reflex loudspeaker system), provides accurate information about the actual excursion of the cone of the loudspeaker. So the information contained in audio power S_2 may be

used to activate the amplifier/attenuator means to function as a fast cone excursion protection.

[0011] A still further embodiment of the loudspeaker protection system according to the invention is ~~characterised~~ characterized in that the processing means are capable of summing S_j over a specified subrange of possible values of j, where j is in the range from 1, 2, ... n.

[0012] Advantageously, summing S_j over possibly all values from 1 to n reveals a value of S which represents information about the ~~momentaneous~~ instantaneous electrical dissipation in the loudspeaker. ~~So~~ Hence, the information contained in S may be used to activate the amplifier/attenuator means to function as a fast thermal protection.

[0013] In ~~practise~~ practice, some sensible and fast enough summed value or combination of values S_j will be used so that if these respective values approximate some ~~normalised~~ normalized individual value S_{norm}, the amplifier/attenuator means are controlled by the processing means to take proper action to protect the loudspeaker.

[0014] ~~By i~~In a still further embodiment of the invention, by determining S_j or any summation thereof every 0.001 - 2 sec., or in particular every .1 - 1 sec., updated data are derived such that an

accurate and reliable protection is available at all times. Advantageously, the present invention can be applied not only in the low frequency range for bass loudspeakers, but also for mid-~~tone~~ range and high-~~tone~~ range (tweeter) loudspeakers.

[0015] Principally, various values and value control methods are possible for the amplifier/attenuator means, but preferably, in another embodiment of the loudspeaker protection system, they are controlled ~~such~~ by the processing means such that attenuation factors of the amplifier/attenuator means are proportional to:

$$1 / \sqrt{\alpha} + ß_j \ (1 - 1 / \sqrt{\alpha})$$

where $\alpha = S/S_{norm}$, and $ß_j$ represents a factor whose value depends empirically on the particular frequency band j.

[0016] Still another embodiment of the loudspeaker protection system according to the invention is ~~characterised~~ characterized in that the loudspeaker protection system comprises a series arrangement of the loudspeaker and a measuring element, such as a resistance, coupled to ground, ~~whose~~ in which a common connection point is coupled to the processing means to account for actual impedance data of the loudspeaker.

[0017] Advantageously, measurement of actual impedance data of the loudspeaker improves reliability and accuracy of the protection system.

[0018] It is preferred that the processing means is arranged to initiate control in a shorter amount of time than ~~that~~ the time during which the control is withdrawn.

[0019] An advantage ~~thereof~~ is that this way of starting and completing control is less audible and disturbing for the human ear.

BRIEF DESCRIPTION OF THE DRAWING

[0020] ~~At present~~Herein, the loudspeaker protection system according to the invention will be elucidated further together with its additional advantages while reference is being made to the appended drawing~~. In the drawing~~, in which:

[0021] Fig. 1 shows a schematic representation ~~to illustrate~~ illustrating possible embodiments of the loudspeaker protection system according to the present invention; and

[0022] Fig. 2 shows graphs of the impedance versus frequency of two types of loudspeakers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Fig. 1 shows a ~~possible~~ loudspeaker protection system 1 in accordance with the invention. The system 1 comprises an audio signal input terminal 2 connected to a ~~possible~~ dividing amplifier A0, which is connected to a parallel arrangement of filter means of the system 1, ~~which~~ this filter means ~~are~~ being arranged as band-pass filters BPF1-BPF(n-1), and possibly BPF(n), whereby the latter

may be a high-pass filter. Each of the respective filter means BPF is connected to controllable amplifier/attenuator means, shown as separate amplifiers A11-A1(n) and attenuators A21-A2(n). Each of the amplifier/attenuator means is provided with a control input Vc1-Vc(n), such that the amplification or attenuation of the amplifier/attenuator means can be controlled in dependence on the respective control signals there~~-~~on. Output signals designated v1-v(n) are applied as inputs to an adder 3, which, in turn, is connected to an amplifier A3 and then to a loudspeaker LS~~, which is~~ coupled to ~~earth~~ground. The system 1 comprises processing means 4 fed by the output signals v1-vn through peak-value detectors P1-Pn. The peak-value detectors P1-Pn finally input signals V1-Vn, which are representative ~~for~~ of the peak values of the output signals v1-vn. The processing means 4 provides control signals Vc1-Vc(n-1) to the correspondingly designated control inputs of the amplifier/attenuator means. Additionally, in a further embodiment of the loudspeaker protection system 1, further control information may be derived from a measuring element, such as a resistor Rm, which, through a further band-pass filter BPMm, an amplifier Am and a further peak detector Pm, ~~which~~ provides control information ~~is also conveyed~~ to the processing means 4. Principally, all constituting elements of the loudspeaker protection system 1 can be implemented in either an analog, or digital, or hybrid way, whereby conversion takes place by means of suitable A/D and D/A ~~converters~~ converters and, where possible, multiplexers are applied to reduce

the number of necessary ~~convertors~~converters. The processing means 4 can be implemented by means of a properly programmed processor, such as a microprocessor or computer.

[0024] The functioning of the loudspeaker protection system 1 is as follows. The audio signal on input terminal 2 is divided in separate frequency bands by the filter means BPF1-BPFn. The audio power S_j in each of the frequency bands j is ~~being~~ calculated repeatedly by the processing means 4 in the embodiment as shown ~~as~~using the formula:

$$S_j = v_{jtop}^2 * R\{Y_j\} * (A_3)^2,$$

where v_{jtop} is the peak value of the amplitude of the frequency components in frequency band j, $R\{Y_j\}$ is the real part of the electric admittance of the loudspeaker in frequency band j and A_3 is the gain of amplifier A3. The latter may come from a table with pre-measured data concerning the electric admittance of the loudspeaker LS concerned, or may be actually measured by means of the measuring element Rm, which will be elucidated later. The number n of frequency bands may, for example, be between 2 and 8. The lowest frequency band contains information in the form of the audio power S_1 present therein, which is a good estimate for the resistance of the voice coil of the loudspeaker. This resistance increases with the actual temperature of the voice coil. If, in an audio signal at a certain moment, audio power S_1 exceeds a ~~normalised~~ normalized loudspeaker value S_{norm}, then the

amplifier/attenuator means are activated by the processing means 4 and the control signal Vc1 is influenced to decrease the audio power S_1, which reduces critical audio power to the loudspeaker, such that a ~~long~~ long-term (slow) thermal protection thereof is achieved. The output audio power S_1 is controllably reduced as far as necessary for protection of the loudspeaker LS, whose full power range can thus safely be used.

[0025] Similarly audio power S_2, for example, containing frequency components around the ~~so~~ so-called Helmholtz frequency and above (e.g., between 25 Hz and 85 Hz for a bass reflex loudspeaker system), provides accurate information about the actual excursion of the cone of the loudspeaker. An example of an Helmholtz band and Helmholtz frequency f_H is shown in ~~fig~~Fig. 2 between f_1 and f_2. The one peak curve as shown is representative for a normal loudspeaker system. ~~So~~ Hence, the information contained in audio power S_2 in the form of audio output power around the Helmholtz frequency, may be used to activate the amplifier/attenuator means to function as a fast cone excursion protection. If the audio power ~~in~~ S_2 exceeds a predetermined level, then this is an indication that the voice coil ~~moves~~ is moving out of its magnetic field and an unwanted large excursion arises. Cone protection is achieved by allowing the processing means 4 to control the output power in audio power S_2 such that it is lowered to an extend that said predetermined level is not exceeded for the

particular loudspeaker. ~~Offcourse~~ Of course, any suitable combination of frequency bands S_j may be used and/or summed to provide the wanted information about excessive cone excursions.

[0026] The following protection that may achieved is a long range or fast thermal protection, protecting against high-level peaks in the audio signal for the loudspeaker. ~~this~~ This can take place by determining, in the processing means 4, the sum S of ~~output~~ audio power S_j in several frequency bands by:

$$S = \Sigma\, v_{jtop}^2 * R\{Y_j\} * (A_3)^2.$$

[0027] If S exceeds a further ~~normalised~~ normalized predetermined value, then control action is taken by the processing means 4 such that finally S decreases and the summed, possibly total, audio power in the loudspeaker decreases, which protects the loudspeaker LS against ~~momentaneous~~ instantaneous high-level audio peaks. The processing means ~~are~~ 4 is capable to determine S_j or any summation S thereof every 0.001 - 2 sec., ~~in particular~~ and more particularly, every .1 - 1 sec. This will generally depend on the expected variations in the audio signal and on the speed of the hardware and software needed to program the processing means 4 properly. Of course, any of the above described protection methods may be combined and performed in any obvious way for either bass, mid-~~tone~~range, or high-~~tone~~ range loudspeakers.

[0028] Control of the attenuation factors Vc1-Vcn will take place gently in order not to attenuate the audio signal too much, and such that the full power range of the loudspeaker LS is still usable. A possible way of control is that the amplifier/attenuator means are controlled ~~such~~ by the processing means such that the attenuation factors of the amplifier/attenuator means are proportional to:

$$1 / \sqrt{\alpha} + ß_j \ (1 - 1 / \sqrt{\alpha})$$

where $\alpha = S/S_{norm}$, S_{norm} represents the further ~~normalised~~ normalized predetermined value of S, and $ß_j$ represents a factor whose value depends empirically on the particular frequency band j. For example, $ß_j$ may be chosen 0, 1/4, 2/4, 3/4, 1. Herein, S may be summed over one or more frequency bands. For example, attenuation (or inverse amplification) in the amplifier/attenuator means can be even more gradually ~~be~~ adjusted proportional to:

$$\{\tau^x + ß_j(1 - \tau^x)\}\{1 / \sqrt{\alpha} + ß_j \ (1 - 1 / \sqrt{\alpha})\}$$

where, for fast thermal protection, τ exceeds 1 and x is a constant to be determined empirically. Generally, it is preferred, for human perception reasons, that the processing means 4 ~~are~~ is arranged to initiate control in a shorter amount of time than that during which the control is withdrawn.

[0029] In the ~~above~~ above-mentioned further embodiment, the loudspeaker protection system 1 comprises the measuring element Rm. The data concerning the ~~momentaneous~~ instantaneous impedance and

voltage across the element Rm on, for example, common connection point P can be used by the processing means 4, instead of corresponding data in a memory table of the processing means 4, to have actual, and thus more accurate and reliable, values available for each possible combination of the above mentioned protection methods.

ABSTRACT~~:~~ OF THE DISCLOSURE

A loudspeaker protection system ~~comprises~~ includes a filter ~~means~~ arrangement for defining one or more frequency bands of an audio signal, controllable amplifier/attenuator ~~means~~ combinations coupled to the filter ~~means~~arrangement, and a processing ~~means~~ arrangement coupled to control the amplifier/attenuator ~~means~~combinations, such as to determine audio power in at least one of ~~said~~ the frequency bands representing relevant loudspeaker protection information used for selective audio power control in ~~said~~ the at least one frequency band. This system has the features for a fast and/or slow thermal protection, as well as for a cone excursion protection, all for a loudspeaker in such a system.

~~Fig. 1~~